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Density of Gutta Percha by Weight in Straight Root Canals and Curved Root Canals after Single Cone, Cold Lateral, and Warm Vertical Condensation

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DENSITY OF GUTTA PERCHA BY WEIGHT IN STRAIGHT ROOT CANALS AND CURVED ROOT CANALS AFTER SINGLE CONE, COLD LATERAL, AND WARM VERTICAL CONDENSATION

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

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Abstract

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The purpose of this study was to compare the density of gutta percha following three different obturation techniques using two split-tooth models. One split-tooth model was constructed with a straight rooted maxillary incisor and the other with the curved palatal root of a maxillary molar. Each tooth was obturated using single cone, cold lateral, and warm vertical obturation techniques without sealer. Each obturation technique was performed 20 times for each of the root systems. The weights of the gutta percha were recorded for each root type and obturation technique by subtracting the post-fill weight from the pre-fill weight of the two split-tooth models. Results show that in the straight canal, the three obturation techniques are significantly different ($p < 0.0001$). The warm vertical technique had the largest weight of gutta percha, followed by the single cone, and lastly by the cold lateral condensation group. In the curved canal, the three fill types were also significantly different ($p < 0.0001$). The warm vertical and single cone obturation techniques were not significantly different from one another but were significantly greater in gutta percha weight than the cold lateral technique. In conclusion, within curved canals, warm vertical and single cone techniques were more dense than cold lateral condensation. In the straight canal, the warm vertical was more dense than the single cone which was more dense than the cold lateral technique.

{CHAPTER 1 Introduction}

One of the main goals of endodontic treatment is to effectively clean and shape, both mechanically and chemically, the root canal system in order to eliminate as many microorganisms as possible while preparing the canal for adequate three-dimensional obturation (1). Three-dimensional obturation of the canal space with a dense fill of gutta percha and minimal sealer is optimal for a greater chance of endodontic success (2). Although sealer is necessary for decreased leakage, the ideal obturation method would densely fill the canal in three dimensions with gutta percha, while leaving only a thin layer of sealer between the gutta percha and the canal wall (2, 5-7). Ingle's classic study reported that 58% of root canal failures were due to incomplete obturation of the root canal space (3). Sjogren et al found that obturation technique is a factor influencing the success or failure of root canal therapy (4). The best method to achieve complete obturation of the root canal system is constantly under study and debate.

Cold lateral condensation is the gold standard for filling root canals to which most obturation techniques are compared (8, 3). Traditionally, obturation involved .02 taper gutta percha master cones that were laterally condensed with accessory cones following hand file instrumentation. However, lateral condensation techniques have been shown to contain a greater percentage of sealer than warm vertical and single cone techniques, therefore increasing the probability for leakage and decreasing the chances for success (9, 2). Lateral condensation techniques also may be more time consuming and may place excessive forces upon the teeth, which could potentially lead to root fracture.

Recently, gutta percha cones in .04 and .06 taper have been introduced, to match the dimensions of the nickel titanium files used to prepare the canals. Since these cones are manufactured to match the shape of the preparation, single cone obturation may be a viable option for some canals. Single cone obturation has the advantage of being a very fast and easy method of root canal obturation. Antonopoulas et al found that lateral condensation and single cone obturation yielded similar sealing abilities, whereas Narracott found that single cone techniques showed less leakage than lateral condensation techniques (10, 11). An in vivo study on treatment outcomes found no significant differences from those patients whose root canals were obturated with single cone versus cold lateral condensation following 6 to 18 month recalls (12).

Also with the advent of greater tapered file systems and gutta percha cones, warm vertical condensation has come to the forefront for root canal obturation. This technique was introduced by Shilder but has been modified by Buchanan as the continuous wave of condensation technique (1, 13). Lea et al found that the continuous wave warm vertical condensation technique contained a greater density of gutta percha by weight as compared to the cold lateral condensation technique (14). Wu et al however found greater fluid movement in the coronal two thirds of the root canal in warm vertical techniques when compared to single cone and cold lateral condensation techniques, but there was no significant difference in fluid movement between the cold lateral and single cone techniques (15). Several studies have shown that gutta percha in warm vertical obturation techniques adapts better to canal walls, canal irregularities, and lateral canals when compared to cold condensation techniques (16-18).

Since available rotary instrument configurations may not mirror irregularities in the canal morphology, matching points may not adequately obturate a given canal. The inherent taper and curvature of a canal may influence the type of obturation technique that works best for a given root canal system. For example, a study by Wilson and Baumgartner advocated the use of the matched taper single cone technique in smaller, more curved canals (19). Earlier studies by Gordon et al found no significant difference in the amount of gutta percha in .06 single cone obturation versus .02 cone plus accessory cone lateral condensation in curved canals; however, this study used sealer which could have made up the difference in densities (20).

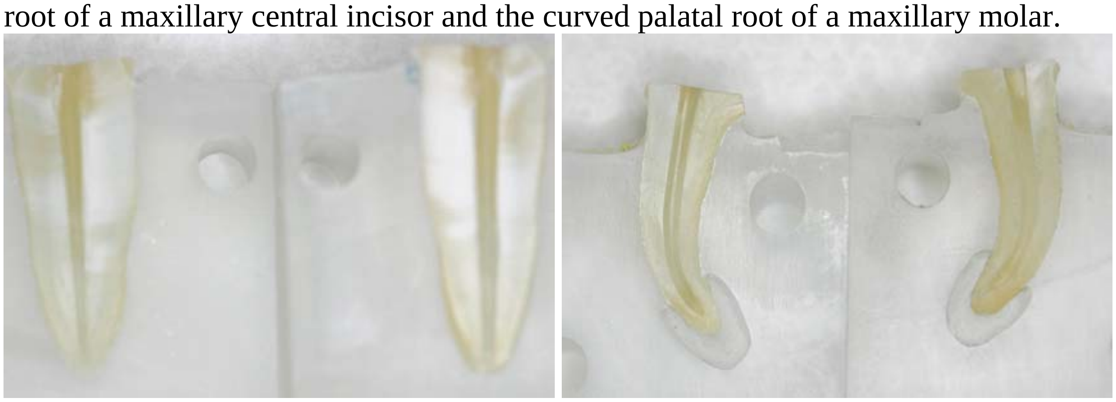
Knowing the formula: density = mass / volume, and using a system in which the volume of the canals is uniform and in which the gutta percha is uniform for each of the obturation techniques, we can say that a greater mass, or weight, of gutta percha within the root canal system yields a greater density of obturation. Increased density of gutta percha in an obturated root canal system will result in fewer voids filled by sealer and could therefore create a better seal both apically and coronally.

The purpose of the current study is to use a split-tooth model to compare the amount of gutta percha by weight following obturation with a single .06 tapered gutta-percha cone, .02 tapered gutta percha plus accessory cones, and warm vertical condensation without sealer in both straight canals and curved canals that have all been prepared with .06 tapered rotary files.

{CHAPTER 2 Materials and Methods}

A previously extracted human maxillary central incisor with a straight canal and a curved palatal root of a maxillary molar were chosen to produce a split-tooth model to be used for the obturations in this study. The teeth were accessed using a #4 round bur (Brassler, Savannah, GA) and access into the canals was gained by using ISO size 8, 10, and 15 stainless steel hand files. The crowns of the teeth were resected down to the cemento-enamel junction using a diamond wheel (Brassler) in a high speed handpiece. The palatal root of the maxillary molar was carefully sectioned from the other tooth roots. The roots were then embedded in a block of clear plastic casting resin (ETI, Fields Landing, CA) and left to cure for 48 hours at room temperature. A drill press was used to place two alignment holes drilled perpendicular to the long axis of the tooth in a mesial-distal direction in opposing corners of the acrylic block. The tooth roots were then sectioned vertically in a buccal-lingual direction through the center of the canals using a Buehler IsoMet saw (Buehler Ltd., Lake Bluff, IL) with a 150 *u*-m diamond blade. The working lengths were established by separating the sections and placing a #15 K-file (Dentsply Maillefer, Johnson City, TN) in the canal and measuring to 1mm from the apex of the root. The two halves of the root could then be re-approximated and held in place by two bolts and two nuts placed through the previously drilled holes. Each of the canals were cleaned and shaped in a crown down fashion using .06 taper K3 NiTi rotary instruments (SybronEndo, Orange, CA) used according to the manufacturers directions. Irrigation with 5.25% sodium hypochlorite was used following each rotary instrument and a size #10 K-file (Dentsply Maillefer, Johnson City, TN) was used to establish patency following irrigation. The central incisor was instrumented to a master apical file of 50/.06 to a working length of 14 millimeters, and the palatal root of the molar was instrumented to a master apical file of 40/.06 to a working length of 12 millimeters. The canals were then irrigated with saline, dried with paper points, and allowed to dry for 24 hours so that the weight of the liquid irrigants would not affect the measurements.

Figure 1. Photos from left to right illustrate the split-tooth model with the straight single root of a maxillary central incisor and the curved palatal root of a maxillary molar.



Single Cone Obturation

The entire split-tooth model was weighed with a Mettler-Toledo XS 64 microbalance (Mettler-Toledo, Inc., Columbus, OH) to obtain a pre-obturation weight. The canals were then obturated with a single .06 gutta percha cone (Diadent Group International Burnaby, BC Canada) of corresponding file sizes (50/.06 for the straight canal and 40/.06 for the curved canal) used during the rotary instrumentation of the canal. No sealer was used in any of the obturations of this study. The gutta percha was seared off at the canal orifice with a System B unit (SybronEndo, Orange, CA) at 210 degrees Celcius, per manufacturers directions, condensed with a #2 Buchannan plugger (SybronEndo, Orange, CA) and the excess removed flush with the orifice using a size #15 surgical blade. The tooth was weighed again with the Mettler-Toledo microbalance to obtain a post-obturation weight. The weight of the gutta percha in the obturated canal space was obtained by subtracting the weight of the gutta percha in the post-obturated system from the weight of the pre-obturated system. The gutta percha was then removed by unscrewing the nuts and bolts and splitting the halves of the teeth. The canals were cleaned thoroughly and care was taken not to leave any residual gutta percha inside the canal system. This process was repeated 20 times.

Figure 2. Photos from left to right illustrate the single cone obturation of the straight canal and the curved canal.

Cold Lateral Condensation

The canals were again weighed before obturation. They were then obturated with a .029 taper master gutta percha cone (Diadent Group International Burnaby, BC Canada) of corresponding file tip size of the last rotary file used in instrumentation (50/.06 for the straight canal and 40/.06 for the curved canal). A nickel-titanium D11T spreader was used in the lateral condensation and was initially taken to within 1mm of working length. Accessory cones of the size 15/.029 (Diadent Group International Burnaby, BC Canada) were used in the lateral condensation. These cones were chosen as accessory cones in order to use gutta percha from the same company to eliminate any weight differences that may occur from using different gutta percha from different manufacturers. The canals were laterally condensed until they were adequately obturated to the orifice. Again, no sealer was used in obturation. The gutta percha cones were seared off at the canal orifice with a System B unit at 210 degrees Celcius, condensed with a #2 Buchannan plugger and the excess removed flush with the orifice using a size #15 surgical blade. The teeth were again weighed with the microbalance. The tooth was opened and the canal was cleaned thoroughly. This process was repeated 20 times.

Figure 3. Photos from left to right illustrate the cold lateral condensation of the straight and
the curved canal.

Warm Vertical Condensation (Continuous Wave of Condensation)

The same canals were again weighed empty and were lastly obturated using warm vertical condensation. A single 0.06 taper gutta percha cone (Diadent Group International Burnaby, BC Canada) of the same size as the last rotary file used (50/.06 for the straight canal and 40/.06 for the curved canal) was placed into the canals to respective working lengths. Using the 0.10 tip in the System B unit at 210 degrees Celcius, the gutta percha was vertically condensed to within 5 mm of the working length and the excess gutta percha coronal to this mark was removed upon removal of the System B tip. A plugger was used to compact the gutta percha. The Obtura II unit (Obtura Spartan, Fenton, MO) set at 200 degrees Celcius was then used to backfill the canal from the 5mm mark to the canal orifice. A #2 Buchannan plugger was used to condense the gutta percha at the orifice and the excess was removed flush with the orifice with a #15 surgical blade. The gutta percha used in the Obtura unit was a Diadent 60/.06 cone. This was done in order to maintain comparability using the same brand of gutta percha throughout this experiment as different brands of gutta percha may have different densities. The tooth was again weighed using the microbalance and then cleaned. This process was also repeated 20 times.

Figure 4. Photos from left to right illustrate the warm vertical condensation of the straight and the curved canal

{CHAPTER 3 Results}

The mean differences in pre-obturation weight and post-obturation weight for the three obturation techniques were compared using analysis of variance (ANOVA), followed by Tukey's HSD to identify whether statistical group differences occurred. Analyses were performed using JMP software (SAS Institute Inc., Cary NC, version 7.0). Gutta-percha weight statistics for the straight and curved root canal systems are summarized in Table 1.

Within the straight canal, the individual gutta percha obturation weights and 95% Confidence Interval (CI) on the mean are shown in the top panel of Table 1 and plotted in the top panel of Figure 5. The three obturation techniques within the straight canal teeth are significantly different [$F (2, 57) = 67.7$, $p < .0001$]. Tukey's HSD indicated that each of the three obturation techniques were different from one another. The warm vertical technique had the largest average weight of gutta percha, while the single cone had the second largest average weight of gutta percha, followed lastly by the cold lateral technique which had the least amount of gutta percha by weight.

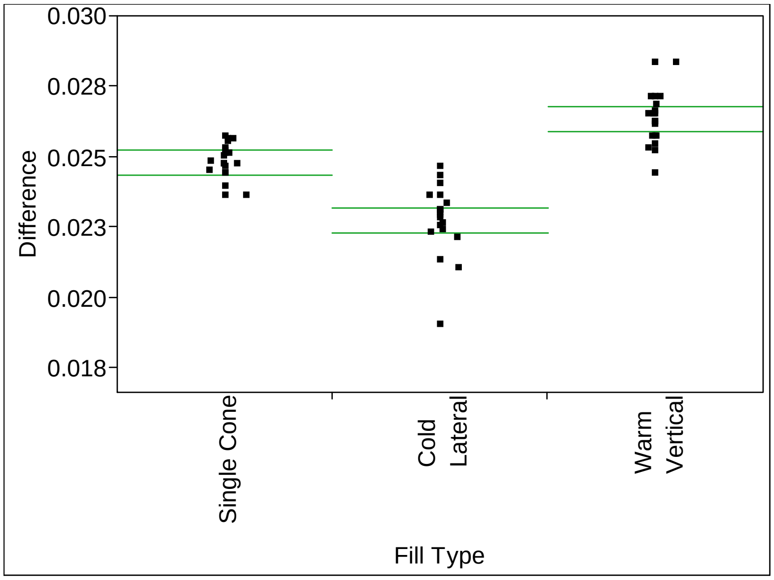
In the curved canal, the individual gutta percha obturation weights and 95% Confidence Interval (CI) on the mean are shown in the bottom panel of Table 1 and plotted in the bottom panel of Figure 5. The three obturation methods were significantly different [$F (2, 57) = 23.6$, $p < .0001$]. Tukey's HSD indicated that the warm vertical and single cone techniques were not significantly different from one another. The cold lateral technique had significantly less mean weight of gutta percha than either of the other two obturation techniques.

Table 1: Gutta Percha Weight

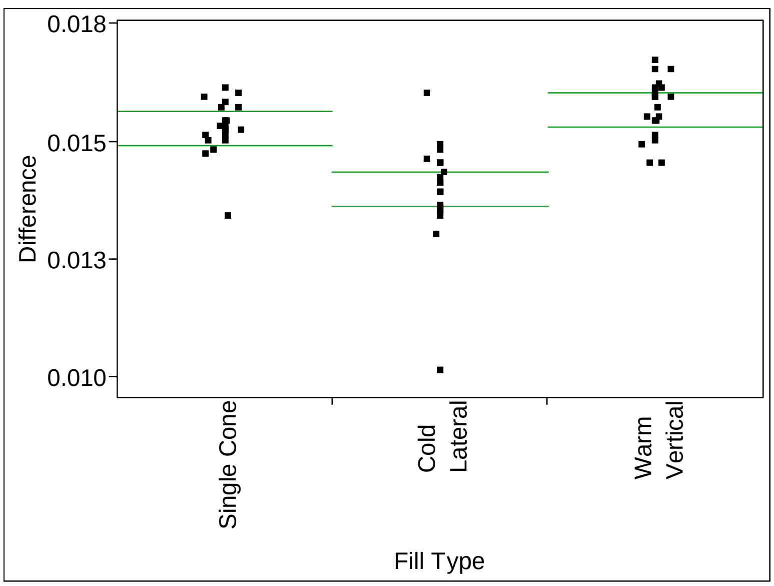
Obturation technique	Canal = Straight			
	Mean	SD	95% CI	
Single Cone	0.0248	0.0006	0.0244	0.0252
Cold Lateral	0.0227	0.0012	0.0223	0.0232
Warm Vertical	0.0263	0.0010	0.0259	0.0268
Obturation technique	**Canal = Curved**			
	Mean	SD	95% CI	
Single Cone	0.0153	0.0006	0.0149	0.0156
Cold Lateral	0.0140	0.0011	0.0136	0.0143
Warm Vertical	0.0157	0.0006	0.0153	0.0160

Figure 5. Individual gutta percha obturation weights and 95% Confidence Intervals

Canal = Straight



Canal = Curved



{CHAPTER 4 Discussion}

It has been shown that the greater the weight of gutta percha in a canal, thereby reducing the sealer volume in that canal, the less leakage would occur (5). This would theoretically increase the chances for endodontic success (2). By comparing cold lateral condensation, single cone obturation, and warm vertical obturation techniques in canals of differing curvatures, a determination can be made for which method is better for getting a greater weight of gutta percha in these varying canals and thereby increasing the probability for successful root canal therapy.

The weights per unit volume, or densities for each of the canal systems and obturation methods were compared. In a system with a constant volume, such as the split-tooth models, an increase in gutta percha weight equals an increase in gutta percha density. Such a dense “three-dimensional root canal filling” was advocated by Schilder (1). Increased density of gutta percha in an obturated root canal system will result in fewer voids filled by sealer and could therefore create a better seal both apically and coronally.

In the straight root canal system, there were significant differences in all three obtruation techniques [$F (2, 57) = 67.7$, $p < .0001$]. The warm vertical technique produced the greatest weight of gutta percha (mean weight = 0.0263 g) which was significantly greater than the single cone technique (mean weight = 0.0248 g) which was significantly greater than the cold lateral technique (mean weight = 0.0227 g). It has been shown that the warm vertical technique for obturation produces a fill that has a greater capacity to flow into canal irregularities (16-18, 21, 22). It was noted during the course of the current study that the straight canal did have some irregularities that were not eliminated by the cleaning and shaping procedures. It is suspected that these irregularities were better obturated by the warm vertical technique and is therefore the reason this technique produce a significantly greater mass of gutta percha than the single cone technique or the cold lateral technique.

In the curved root canal system, there were significant differences between the cold lateral technique (mean weight = 0.0140 g) when it was compared to the single cone technique (mean weight = 0.0153 g) and the warm vertical technique (mean weight = 0.0157 g). There were not however significant differences between the single cone technique and the warm vertical technique in this canal system. Although the mean weight of gutta-percha was slightly greater in the warm vertical technique when compared to the single cone technique, there was not a statistically significant difference. It was also noted that there were canal irregularities in the curved canal as well that could be better obturated by warm vertical condensation methods than by the single cone or cold lateral techniques.

In the present study it was shown that the cold lateral condensation technique for root canal obturation resulted in a significantly less weight of gutta percha when compared to the warm vertical and single cone techniques. This was true in both straight and curved root canal systems when these canal systems were cleaned and shaped with NiTi rotary instruments to sizes 50/.06 and 40/.06 respectively. It has been shown that cold lateral condensation techniques for obturation produce a non-uniform mass of gutta percha that does not fill the irregularities that are often found in root canal systems (21, 22). The irregularities produced within the mass of gutta percha and the irregularities within the root canal system itself are then filled by sealer. Higher amounts of sealer in obturated root canal systems has been shown to lead to greater leakage both apically and coronally which can have an effect on overall success of the root canal therapy (9, 2, 23, 24).

{CHAPTER 5 Conclusion}

In conclusion, the results of the present study have shown that in both straight and curved root canals, the cold lateral condensation technique had the lowest weight of gutta-percha. In the straight canal, the warm vertical condensation technique yielded the greatest weight of gutta percha followed by the single cone technique which yielded a greater weight of gutta percha than the cold lateral condensation technique. In the curved canal the warm vertical and the single cone techniques yielded very similar gutta percha weights which were both greater than the cold lateral technique.

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